

THE GASTEROMYCETES OF AUSTRALASIA. XII.

THE GENUS SCLERODERMA.

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(Plates xv-xvi; six Text-figures.)

[Read 29th July, 1931.]

The genus *Scleroderma* is placed in the family Sclerodermaceae of the Gasteromycetes and is characterized by the simple peridium, usual irregular method of dehiscence, pulverulent gleba and absence of a definite capillitium. The family is limited to the genera *Scleroderma* and *Pisolithus*, though Fischer (1900, p. 334) included *Melanogaster* and *Corditubera* (members of the Hymenogastraceae), *Pompholyx* and *Sclerangium* (synonyms of *Scleroderma*).

*Scleroderma* is separated from *Pisolithus* by the pulverulent gleba, for in the latter genus the tramal plates become carbonous and persistent. The morphology of the genus is simple. The peridium is composed of hyphae intricately interwoven to form a firm membrane, which in mature specimens is not or seldom clearly differentiated from the periphery of the gleba. It is usually borne on a short rooting base which is firmly attached to the substratum by numerous well developed, fibrous mycelial strands or rhizoids. Occasionally these unite to form definite cords, which sometimes become aggregated and produce a columnar rooting base often many centimetres long. In one species (*S. radicans*) the hyphae which normally form the rhizoids become intricately interwoven to form a columnar, stem-like tissue which penetrates for several centimetres into the sandy soil in which this plant grows (Pl. xvi, fig. 7).

The peridium encloses the gleba. This is at maturity pulverulent and composed of very numerous spores mixed with a few mycelial threads, which are the remnants of the tramal plates. These are usually termed capillitium threads, but this term is scarcely applicable since these structures are not comparable with the capillitium of the Lycoperdaceae. The spores are of two distinct types, reticulate and verrucose, and serve as excellent characters upon which to group the species.

*Development.*

The development of members of this genus is comparatively simple. The plants arise as terminal or lateral inflations on the ends of the rhizoids. Sections of these primordia show them to consist of interwoven hyphae without differentiation or arrangement. When plants are about 5 mm. in diameter, glebal development commences. Deeply staining areas arise scattered through the tissue, being more distinct and numerous centrally, scattered and poorly defined peripherally, the greater part of the plant being as yet undifferentiated. These deeply staining areas become aggregated into dense hyphal knots, closely and intricately interwoven. At the same time the surrounding hyphae of the fructification become more

densely compacted and peripherally become arranged with their long axes predominantly radial. Further development is for a time confined to the knots of hyphae which, in addition to increasing peripherally in numbers, increase in size and shortly become oriented so that most surround a lenticular zone. Those hyphae facing towards the centre of this zone become torn apart, their free apices assume a clavate appearance, and become modified as basidia. They enlarge somewhat, and bear sessilely a variable number of spores. At first but one or two spores are produced upon each, but as development continues this number increases, so that basidia in older plants may bear from four to five spores; but the number and position are seldom constant. Opinions differ as to what happens in this plexus of hyphae and basidia subsequently. Beck (1889) claimed that in *Phlyctospora fuscum* Cda. (which Fischer, 1900, p. 336, placed under *Scleroderma*) when the spores were less than half size they became surrounded by a sheath of hyphal cells which served as nutritive or "nurse" cells. A similar condition was reported by Rabinowitsch (1894) in *Scleroderma Bovista*. Coker and Couch (1928, p. 168) found that with *S. lycoperdooides* Schw. the fertile tissue, including the basidia, was broken down into a translucent, almost structureless mass surrounding and embedding the spores, which at this period were hyaline, smooth and only about half size. They concluded that as the basidia disappeared before the spores were more than half developed, this matrix served as a nutritive substance. I have found in *S. flavidum* that the spores, shortly before they are half grown, are surrounded by a number of loosely attached small and hyaline cells, but that these soon gelatinize and embed the spores in a matrix similar to that recorded by Coker and Couch; and in *S. Bovista* a condition similar to that described by Beck and Rabinowitsch.

Additional hyphal knots continue to develop between others in the tramal tissue, and this process continues until finally the whole of the central tissue of the gleba has become converted into spores (and mucilaginous investment), save the peripheral region and (according to the species) scattered rudiments of the undifferentiated gleba which persists as the so-called capillitium. There is no sharp differentiation between the periphery of the gleba and peridium, the zone being continuously interrupted by partial plates of undifferentiated tissue; consequently it often happens that when dehiscence occurs part of the peridium is torn away and left as a fine membrane covering the spore mass. (This additional tissue has been responsible for the erection of the genera *Stella* and, in part, *Sclerangium*). Thus both tramal plates and peridium are but undifferentiated potential sporogenous tissue. In many plants glebal formation continues until the apical portion of the peridium is almost completely converted, when there remains but a shell which ruptures readily.

The genus has proved a difficult one for the systematist, there being little agreement as to the specific limits of the few known species. This confusion has arisen through attempts being made to base species upon such variable characters as the surface of the peridium, colour of the peridium and gleba, and method of dehiscence. Within limits, these characters are useful, but too variable to be used alone in specific diagnosis. For example in the common species of Australia and New Zealand, *S. flavidum*, the peridium may be almost smooth, finely warted, areolate or, in extreme forms, covered with coarse scales. The colour may range from bright citron-yellow to vinaceous brown. The plant may rupture apically in an irregular manner, or it may break into lobes which become strongly recurved and in old specimens stellate, then resembling certain forms of *S. Geaster*. The

gleba may vary from ferruginous to umber-brown, depending (partly) on age at the time of collection, and the locality in which the plant is growing, and may possess persistent tramal plates, or these may be wanting. This variation is not confined to this species alone, but is exhibited by numerous others; for *S. Bovista* may externally exactly resemble *S. cepa*; similarly *S. flavidum* may resemble *S. aurantium*, and both may resemble *S. Bovista*. After examining a large series of specimens I believe that the spores form one of the most reliable guides, as, if their size and markings are considered, it is often easy to place an otherwise difficult specimen. The spores are either definitely reticulate or else covered with acute spines or blunt verrucae. These characters are not readily seen unless the specimens are mounted in a suitable clearing agent. I use a solution of lactic acid in water, for if spores are mounted in this and heated to boiling point their markings are rendered free from obscuring matter, and may be examined critically. As older workers seldom recognized spore characters, it is often difficult to decide the species with which they were dealing. Many of the species considered valid today were erected by Persoon or Fries, and for an interpretation of these in the light of spore characters it is necessary to refer to Hollos (1904) who was the first clearly to describe and illustrate these structures. His work has therefore come to be regarded as the authoritative one for the common European species. Coker and Couch (1928) have likewise used the spores as one of the critical diagnostic features, with the result that the North American species considered in their publication can be recognized readily. Lloyd (1905) worked over the Australian and New Zealand species, and his work has come to be regarded locally as the standard for this region. Unfortunately he appeared to have had but a scant knowledge of the genus, and ignored the spores in his papers, consequently his diagnoses are of little value. This is exemplified by the material named by him in the collections I have worked over, for collections of *S. flavidum* have been referred to no less than six species, of which three are not known with certainty to occur in this region!

#### SCLERODERMA Persoon.

*Ex Fries, Syst. Myc.,* iii, 1829, p. 44; *Pers., Syn. Meth. Fung.,* 1801, p. 150, *pro parte*.—*Sclerangium* Lev., *Ann. Sci. Nat., ser. 3,* ix, 1843, p. 132.—*Stella* Mass., *Jour. Myc.,* v, 1890, p. 185.

Plants solitary or in groups, subglobose, pyriform or subturbinate. Peridium firm, consisting of a single layer, externally frequently broken into areolae, verrucae or scales; contracted basally into a short rooting base which is firmly attached to the substratum by (usually) an abundant development of mycelial strands. Gleba formed of tramal plates enclosing cavities in which are produced the spores, becoming pulverulent at maturity. Spores globose, coloured, continuous, externally reticulate or verrucose.

*Type Species.*—*Scleroderma aurantium* Pers.

*Distribution.*—World-wide.

The number of species which have been recorded is large, the numerous volumes of Saccardo's *Sylloge fungorum* containing upwards of 60 species; but it is improbable that there are more than about one-sixth this number, the others being synonyms of these or of *Mycenastrum*, with which genus *Scleroderma* was regularly confused by the compilers.

In Australia and New Zealand the genus is represented by the following five species, of which two are confined to Australia. It appears strange that the

common European *S. Geaster*, *S. aurantium* and *S. cepa* have not been found in this region; but of the 95 collections examined, none can be referred to these three well-known species. Equally strange is the absence of *S. Bovista* from Australia, for this appears to be not uncommon in New Zealand.

*Key to the Species.*

Spores strongly reticulate .....	1. <i>S. Bovista</i> .
Spores echinulate or verrucose.	
Spores 6-10 $\mu$ diameter, commonly 6-8 $\mu$ ; finely and densely verruculose .....	2. <i>S. australe</i> .
Spores 10-12 $\mu$ diameter, sharply echinulate; peridium covered with fine, darker coloured, deciduous warts .....	3. <i>S. verrucosum</i> .
Spores usually 11-14 $\mu$ diameter, or larger, coarsely echinulate or verrucose. Peridium thin, leathery and attached by numerous mycelial strands .....	4. <i>S. flavidum</i> .
Peridium thick, hard and woody, usually attached by a firm mycelial taproot .....	5. <i>S. radicans</i> .

1. **SCLERODERMA BOVISTA** Fries. Plate xv, fig. 1; Text-fig. 1.

*Syst. Myc.*, iii, 1829, p. 48.—*S. texense* Berk., *Hook. Lond. Journ. Bot.*, iv, 1845, p. 308.

Plants solitary or gregarious, to 4 cm. diameter, compressed globose, firm, somewhat plicate below, with a short rooting base or almost sessile, and attached firmly to the substratum by a plentiful development of rhizoids. Peridium when dry tough, firm, dehiscing by irregular rupture of the apical portion, rarely by a definite mouth, externally furfuraceous, or less frequently areolate apically, bright sulphur-yellow or more often bay-brown or pallid-umber, often somewhat vinaceous; in section thin, 0·5 mm. or less, yellowish or vinaceous. Gleba at first violaceous, becoming umber-brown; tramal plates often persistent, yellow, hyphae with distinct clamp connections. Spores strongly reticulate, globose, 11-16  $\mu$  (commonly 11-13  $\mu$ ), deep-umber tinged with chocolate, reticulations to 3  $\mu$  tall.

*Habitat*.—Growing amongst grass on sandy or cultivated soil.

*Type Locality*.—Germany.

*Distribution*.—Europe; North America; New Zealand.

New Zealand: Auckland, Buried Village, Wairoa, 2/27, J. B. Cleland, G.H.C.; Whakarewarewa State Forest Nursery, 5/28, G.H.C.; Taranaki, Botanical Gardens, New Plymouth, 2/27, G.H.C.; Wellington, Wanganui, 4/25, D. W. McKenzie; Palmerston North, 5/30, 2/31, G.H.C.; Weraroa, 3/25, J. C. Neill.

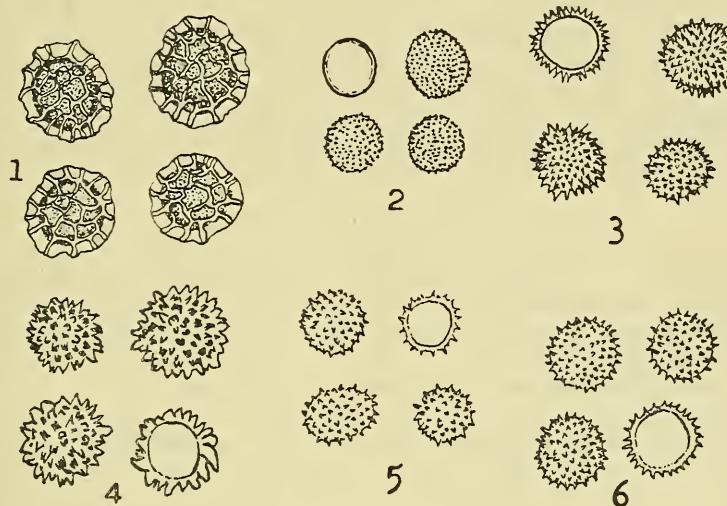
The characters of this species are the strongly reticulated spores, thin but firm, usually externally smooth peridium, and subsistent yellow tramal plates, the hyphae of which possess abundant clamp connections.

Owing to the confusion which exists in literature, few workers are agreed as to the characters of this species. I am following Hollos (1904, p. 132), Rea (1922, p. 49) and Coker and Couch (1928, p. 163) in considering it to be the plant described above.

As the plant normally grows it is firm and somewhat globose, dark in colour and with a well-developed rooting base; but collections from the Rotorua district (New Zealand) are quite yellow, and more lax. The spores are identical in both, however, so that it is not practicable to maintain these yellow plants as distinct, especially as intermediate forms occur.

It appears strange that the species has not been represented in Australia in the abundant collections in the possession of Dr. Cleland. True, it has been recorded by Cooke (1892, p. 240) from Victoria, New South Wales and Queensland;

but as both he and Berkeley confused the plant with *S. flavidum* (repeatedly identifying this as *S. Bovista*, as the collections at Kew show), it is evident no reliance can be placed upon his records. Lloyd (1905, p. 14) stated that at Kew there were several collections of a plant he called *S. texense*, and considered this was a form of *S. Bovista*. But as his diagnosis was based on the subpersistent tramal plates, a character equally present in *S. flavidum*, it becomes evident that his records, too, are inaccurate.



Text-figs. 1-6.

- 1.—*Scleroderma Bovista*. Spores showing reticulations.
  - 2.—*Scleroderma australe*. Spores showing fine verrucae.
  - 3.—*Scleroderma flavidum*. Spores from typical form.
  - 4.—*Scleroderma flavidum* forma *macrosporum*. Spores from a plant in which they are larger and more coarsely warted than in the typical form.
  - 5.—*Scleroderma verrucosum*. Spores showing the somewhat sparse spines.
  - 6.—*Scleroderma radicans*. Spores showing spines.
- (All spores are  $\times 1000$ ; they have been drawn with the aid of a projection apparatus, from lactic acid mounts).

*S. Bovista* is often found associated with healthy roots of *Pinus radiata* in the forest nursery at Whakarewarewa, and has been found similarly with strawberries at Palmerston North. It is probable that the species form a mycorrhiza with the former host, since Peyronel (1922) found that *S. "vulgare"* formed mycorrhiza with roots of *Larix decidua* and *Quercus robur* in Italy.

## 2. SCLEBODERMA AUSTRALE Massee. Plate xv, fig. 2; Text-fig. 2.

*Grevillea*, xviii, 1889, p. 26.

Plants solitary or crowded, to 4 cm. diameter, commonly much less, subglobose, pyriform or subturbinate, firm, basally plicate and attached by a short rooting base, or not infrequently sessile and attached by several scattered basal mycelial cords. Peridium when dry tough, tardily rupturing by irregular crevices, lobes in old and weathered plants becoming somewhat recurved and stellate;

externally bright lemon-yellow, often bay-brown, areolate apically, and sometimes with smooth flattened scales of a deeper colour, or almost smooth; in section thin, 0.5 mm., yellowish. Gleba at first violaceous, becoming umber-brown; tramal plates seen usually only in young plants, yellowish. Spores globose, 6-10  $\mu$  (commonly 6-8.5  $\mu$ ), finely verrucose; spines acute at apices, broad at bases and only 0.5  $\mu$  long.

*Habitat*.—Growing solitary or in small groups in sandy soil.

*Type Locality*.—Endeavour River, Queensland.

*Distribution*.—Australia.

Queensland: Endeavour River (Massee, *I.c.*).—New South Wales: Sydney\* (Lloyd, No. 119, as *S. flavidum*); Neutral Bay, 6/12\*, 3/19\*; The Oaks, 6/14\*; Terrigal, 6/14\*; Mt. Irvine, 6/15\* (Lloyd, No. 118, as *S. cepa*); Milson Island, 6/16\*; Kendall, 12/17\*, 3/18\*; Bradley's Head, Sydney, 4/19\*; Sydney, no date\* (two collections); no locality\* (three collections).—Victoria: Grantville, J. T. Paul (Herb. Vic. Dept. Agr., Lloyd, as *S. flavidum*).—South Australia: Mt. Lofty, 7/14\*.

#### SCLERODERMA AUSTRALE, var. IMBRICATUM, n. var.

Peridium to 5 cm. diameter, subturbinate, firm and rigid; attached by a small rooting base, almost sessile; externally covered with coarse imbricate scales, ferruginous in colour; in section to 2.5 mm. thick, bay-brown. Gleba umber-brown. Spores as above.

*Habitat*.—At the base of a tree trunk in burnt ground.

*Distribution*.—Australia.

New South Wales: Narrabeen, 4/15\* (Lloyd identified this as *S. Geaster* and it was so recorded by Cleland and Cheel, *Journ. Proc. Roy. Soc. N.S.W.*, 1, 1916, p. 114).

This usually small species appears to be relatively common in New South Wales, but apparently rare in the other States. It is characterized by the small spores, with their fine verrucae, yellowish colour, usually strongly areolate surface of the peridium, and frequent attachment to the substratum by several stout cord-like rhizoids. Superficially, plants resemble *S. flavidum* in the yellowish colour, areolate upper portion of the peridium, and stellate dehiscence as shown by old and weathered plants; but differ in the much smaller, finely verrucose spores and the frequent darker colour of the surface areolae.

The variety *imbricatum* was identified by Lloyd as *S. Geaster*. It certainly has the thick peridium and imbricate scales of forms of this species; but as the spores are the same as *S. australe* it must be considered as distinct from *S. Geaster*, in which the spores are reticulated (Rea, 1922, p. 50) or imperfectly so (Coker and Couch, 1928, p. 162). The size of the spores of *S. Geaster* is given by Rea as being 12-15  $\mu$ , whereas Coker and Couch state they are but 5-10  $\mu$ . Apart from this aberrant specimen (placed under the variety *imbricatum*) *S. australe* differs from *S. Geaster* in being much smaller, and in its different dehiscence and much thinner wall of the peridium.

The plant agrees well with the description of *S. australe* as published by Massee, so I am using his name; but comparison with the type is no longer possible as, according to Lloyd (1905, p. 14), he was unable to find this at Kew.

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\* An asterisk denotes that the collection in question is in the herbarium of Dr. J. B. Cleland, Adelaide; and where no collector is given, the collection has been made by Dr. Cleland himself.

3. **SCLERODERMA VERRUCOSUM** (Vaillant) Persoon. Plate xv, fig. 3; Text-fig. 5.

*Syn. Meth. Fung.*, 1801, p. 154.—*S. areolatum* Ehrenb., *Sylv. myc. Berol.*, 1818, p. 27.—*S. pandanaceum* F.v.M. ex Berk., *Journ. Linn. Soc.*, xiii, 1872, p. 171.—*S. Bresadolae* Schulz., *Hedw.*, xxiii, 1884, p. 163.—*S. Torrendii* Bres., *Atti I.R. Acc. Sci.*, ser. 3, viii, 1902, p. 132.

Plants solitary, small, to 4 cm. diameter, fragile, depressed globose, not plicate below, contracting into a short stem-like rooting base which is attached to the substratum by mycelial strands. Peridium when dry fragile, lax, dehiscing by a small torn mouth, which later becomes torn and distorted, externally ochraceous or umber, sometimes with a purplish cast, typically covered with small, deciduous, raised, umber warts, more numerous and larger apically, absent near the base, which is smooth and lighter in colour; in section 0·2–0·5 mm. thick, ochraceous. Gleba at first with an olivaceous tinge, becoming umber; tramal plates whitish, becoming dingy-grey, scanty. Spores globose, sometimes subglobose, 9–12  $\mu$  in diameter, pallid ferruginous-brown, closely and coarsely echinulate; spines with acuminate apices, narrow bases, and to 1·5  $\mu$  long.

*Habitat*.—Growing solitary on the ground in sandy soil.

*Type Locality*.—Europe.

*Distribution*.—Europe; Africa; Asia Minor; Australia.

South Australia: Mt. Lofty, 4/24\*.—New South Wales: Hawkesbury River, 6/12, J. B. Cleland (Herb. Vic. Dept. Agr.); Neutral Bay, 6/12\*, 12/15\*, 5/19\*; Mosman, 5/14\*, 5/19\* (Lloyd, No. 520, as *S. verrucosum*); Bulli Pass, 4/14\* (Lloyd, No. 121 as *S. verrucosum*); no locality\* (two collections).

This species may be recognized by its brittle, thin peridium, externally covered with darker warts, the manner of dehiscence, small but distinct rooting base, and the characteristic echinulate spores. The plant is usually smaller in Australia than in Europe, and the spores are also slightly smaller. But as I have small specimens from Europe (ex Bresadola herbarium) which cannot be separated from the Australian plant, it is evident that our plant is but a form of the European one. The species is in North America replaced by the very similar *S. lycoperdooides* Schw., which differs from the Australian plant by the larger spores, different method of dehiscence and subpersistent hyphae of the tramal plates.

4. **SCLERODERMA FLAVIDUM** Ellis and Everhart. Plate xvi, figs. 4, 5; Text-fig. 3.

*Journ. Myc.*, i, 1875, p. 88.—*S. caespitosum* Lloyd, *Myc. Notes*, 1922, p. 1159.—*S. flavidum* var. *fenestratum* Clel. et Cheel, *Trans. Roy. Soc. South Aus.*, xlvi, 1923, p. 75.

Plants solitary or gregarious, sometimes caespitose, growing half buried until maturity, to 5 cm. diameter, firm, pyriform, or subturbinate, often lobed, usually plicate below, contracting into a mass of mycelial fibres, which occasionally form a conspicuous stem-like base. Peridium when dry tough, leathery and seldom brittle, to 1 mm. thick, dehiscing by irregular rupture into several lobes, which in old weathered plants frequently become recurved and stellate; pallid-straw colour, bright lemon-yellow, or tinged vinaceous, often drying dingy-brown, finely areolate above, sometimes almost smooth. Gleba at first olivaceous, becoming dingy-ferruginous or umber-brown; tramal plates often subpersistent, yellow. Spores globose, 10–14  $\mu$  (commonly 10–13  $\mu$ ), coarsely and densely echinulate; spines acuminate pointed, somewhat narrow at their bases, to 1·5  $\mu$  long.

*Habitat*.—Growing on sandy soil, or partially buried in clay or rock cuttings.

*Type Locality.*—New Jersey, North America.

*Distribution.*—North America; Africa; Australia; New Zealand.

South Australia: Kuitpo, 5/21\* (two collections); Mt. Lofty, 7/14\*; near Adelaide, 1930\*; Overland Corner, 12/13\*; Eagle-on-Hill, 1920\* (Lloyd, No. 692, as *S. flavidum*); same locality, 6/21\*; no locality\* (three collections).—New South Wales: Milson Island, 6/12\* (Lloyd, No. 120, as *S. flavidum*); Sydney, 4/19\*; east of Broken Hill, Dr. Pulleine\*; Narrabri, 10/18\* (Lloyd, No. 532, as *S. aurantium*).—Western Australia: Donnybrook, 8/26\*; Dwarda, 8/26, W. M. Carne; Ludlow, 8/20, J. Clark (these two collections in herb. Dept. Agr. W. Aus.).—New Zealand: Wellington, 5/22, J. B. Cleland\*.

forma MACROSPORUM. Text-fig. 4.

Spores larger, to 19  $\mu$  (commonly 14–16  $\mu$ ) and with more coarse spines, which sometimes appear as fused warts. Otherwise identical with the typical form.

*Distribution.*—South Australia: Adelaide, Mr. Zietz\*; Mt. Lofty, 5/10\*, 7/20\*, 3/24\*, 6/25\*; Mt. Remarkable, 8/27\*; no locality\* (eight collections).—New South Wales: Sydney\*; Bibbenluke, 3/13\*.—Victoria: Dimboola, 7/90, 6/91 (two collections, the former identified by Lloyd as *S. Geaster*, the latter as *S. Bovista*; both in herb. Vic. Dept. Agr.); Ararat, 5/18, E. J. Semmens\*; Dandenong, 7/17, C. C. Brittlebank\*.—Western Australia: Pemberton, 8/26\* (two collections); Mundaring, 7/25, W. M. Carne.—Tasmania: No locality, L. Rodway.—New Zealand: Auckland, Waitakere, 9/21, D. Miller; Rotorua, 7/23, G.H.C.; Wellington, Botanic Gardens, 5/22, 10/22, 1/23, G.H.C. (seven collections); Kelburn, 10/23, G.H.C.; Nelson, 2/20, G.H.C. (Lloyd, as *S. cepa*); Otago, Deborah Bay, 9/26, Miss H. K. Dalrymple; Dunedin, 5/22, 9/22, 7/23, Miss Dalrymple (all in writer's herbarium).

The characters of the species (typical form) are the firm, areolate, relatively thick peridium, method of dehiscence and frequent stellate appearance of old specimens, subsistent tramal plates, and definitely echinulate spores. The form *macrosporum* appears to differ only in that the spores are larger and more coarsely warted; but as numerous intermediate forms occur it is not possible to separate it other than as a form.

The species has doubtless been the basis of most of the records by Cooke (1892, p. 240) of the occurrence in Australia of *S. aurantium* (many plants being yellow in colour), *S. Geaster* (as in old plants the peridium becomes lobed and the lobes recurved and stellate), and *S. vulgare* (which consists of both *S. aurantium* and *S. cepa*); for it is decidedly variable in size, form, colour and surface markings and the degree of development of the mycelial rooting base. From *S. aurantium* and *S. Geaster* it is separated by the echinulate spores (reticulate in these two species), and from *S. cepa* (its nearest relative apparently) by the usually larger spores, and especially in the thicker, differently coloured, areolate peridium. As I have shown above, Lloyd had difficulty with the species, for he named different collections from Australia *S. aurantium*, *S. flavidum*, *S. Geaster*, *S. Bovista*, (and from New Zealand) *S. cepa* and *S. caespitosum* (this last being based on a form not uncommon in New Zealand where it grows in rock cuttings, the plants being compacted together owing to the limited space available in the rock crevices in which it develops). But this is scarcely to be wondered at, since he attempted diagnosis upon the nature of the surface of the peridium and manner of dehiscence, characters which are worthless specifically in this difficult genus.

Judging from the numerous collections I have examined, this would appear to be the most frequent and variable species in Australia. It is not practicable to

maintain the variety *fenestratum*, for it appears in both large and normal spored forms and in addition in other species (as *S. radicans*). Brittlebank stated (*vide* Cleland and Cheel, 1923, p. 76) that the species was found at Dandenong to parasitize the roots of roses.

5. *SCLERODERMA RADICANS* Lloyd. Plate xvi, figs. 6, 7; Text-fig. 6.

*Mycological Notes*, 1906, p. 246.

Plants solitary, to 5 cm. diameter, subglobose, obovate or subpyriform, firm, plicate below, with usually a strong compact mycelial rooting base which is not broken into fibres but forms a solidly interwoven tissue of hyphae and sand. Peridium when dry hard, firm and woody, dehiscing by irregular breaking away of the upper portion, not lobed, long indehiscent, externally furfuraceous or minutely and irregularly areolate, pallid-white, becoming ochraceous; in section to 5 mm. thick, commonly 1.5–2 mm., but thicker below and pallid-ochraceous. Gleba at first ferruginous, becoming umber; tramal plates white, becoming greyish, scanty and practically disappearing in old plants. Spores globose, chestnut-brown, 12–14  $\mu$  (up to 16  $\mu$ ), densely, closely verrucose-echinulate; spines acuminate at their apices, moderately broad at their bases, and (including the wall of the spore) to 2  $\mu$  long.

*Habitat*.—Growing under scrub, often buried in sand.

*Type Locality*.—Bank of the Wimmera River, Victoria.

*Distribution*.—Australia.

Victoria: Wimmera River, F. M. Reader (Lloyd, *l.c.*).—New South Wales: Baradine, 10/18\*; Wangan, 10/18\* (two collections, Lloyd, Nos. 553, 554, as *S. flavidum*); Narrabri, 10/18\*.—South Australia: Murray River\*; probably near Overland Corner\*.—Western Australia: Bindoon, 9/25, W. M. Carne.

The species is characterized by the thick, hard and woody peridium, which basally attains a thickness of 5 mm., pallid colour, greyish, scantily developed tramal plates, and peculiar rooting base. This last consists of a dense tissue of interwoven hyphae in part mixed with sand, and is quite distinct from the fibrous rooting system of other species recorded herein. It was upon this character that Lloyd erected the species; but as I have shown, it differs in many other particulars from *S. cepa*, with which Lloyd stated it was closely related (possibly because of the usually smooth peridium). The spores are close to those of *S. flavidum*, so that plants lacking the peculiar base might be placed under that species; but the hard and woody, thick, light-coloured peridium and scanty tramal tissue serve to distinguish it.

*Doubtful and Excluded Species.*

a. *Scleroderma aurantium* Pers.—Recorded by Lloyd (*Letter 66*, 1917, p. 15) from Australia. This is a misdetermination of *S. flavidum* as has been shown under this species.

b. *Scleroderma aureum* Mass., *Grev.*, xviii, 1889, p. 26.—Recorded by Massee from New Guinea. It was said to possess smooth spores 5  $\mu$  in diameter, which seems improbable. The description reads as if the species were based on an immature specimen of *S. flavidum*, but the matter cannot be solved apparently, since Lloyd (1905, p. 14) stated that he was unable to find the type at Kew.

c. *Scleroderma cepa* Pers.—Lloyd frequently recorded this species from Australia (*Letter 17*, 1907, p. 3; *Letter 23*, 1908, p. 3; *Letter 30*, 1911, p. 6; *Letter 53*, 1914, p. 14; *Letter 62*, 1916, p. 2; *Letter 63*, 1916, p. 5–8; *Letter 66*, 1917, p. 3;

*Letter 67, 1918, p. 10; Myc. Notes, 1921, p. 1074; Myc. Notes, 1922, p. 1120*), from Tasmania (*Myc. Notes, 1921, p. 1089*) and New Zealand (*Letter 8, 1905, p. 2; Letter 67, 1918, p. 2*; and *Myc. Notes, 1922, p. 1160*). But from his notes and the specimens I have examined I believe his records to be based on young specimens of *S. flavidum* and mature plants of *S. Bovista*. (See his determinations under these two species). A stipitate form he figured (*Myc. Notes, 1918, p. 759*) as *S. columnare*. This appears to be based on a specimen of *S. Bovista* with a somewhat abnormal development of the stem-like base.

*d. S. Geaster* Fr.—*Lloyd (Myc. Notes, 1906, p. 246; Letter 61, 1916, p. 3)* recorded this species from Australia and (*Myc. Notes, 1923, p. 1186*) from New Zealand. I have examined specimens he has so determined and find two are typically *S. flavidum*, the third being *S. australe* var. *imbricatum*. Cooke (1892, p. 240) recorded the species from every State in Australia and also from Tasmania; but his records appear to be based on *S. flavidum*, as numerous collections at Kew labelled *S. Geaster* are of this species.

*e. S. olivaceum* (Cke. et Mass.) de Toni.—This is a synonym of *Mycenastrum corium* (Guers.) Desv.

*f. S. pandanaceum* F.v.Muell. ex Berk., *Journ. Linn. Soc.*, xiii, 1872, p. 171.—This I believe to be a synonym of *S. verrucosum*, although the description is so poor as to make specific diagnosis impossible. Lloyd (1905, p. 14) was unable to find the type at Kew.

*g. S. phaeotrichum* (Berk.) de Toni.—This is a synonym of *Mycenastrum corium*.

*h. Scleroderma (Areolaria) strobolina* Kalch.—This is a synonym of *Phellorina strobilina* Kalchbr. et Cke.

*i. S. umbrina* Cke. et Mass.—This is a synonym of *Pisolithus tinctorius* (Pers.) Coker et Couch.

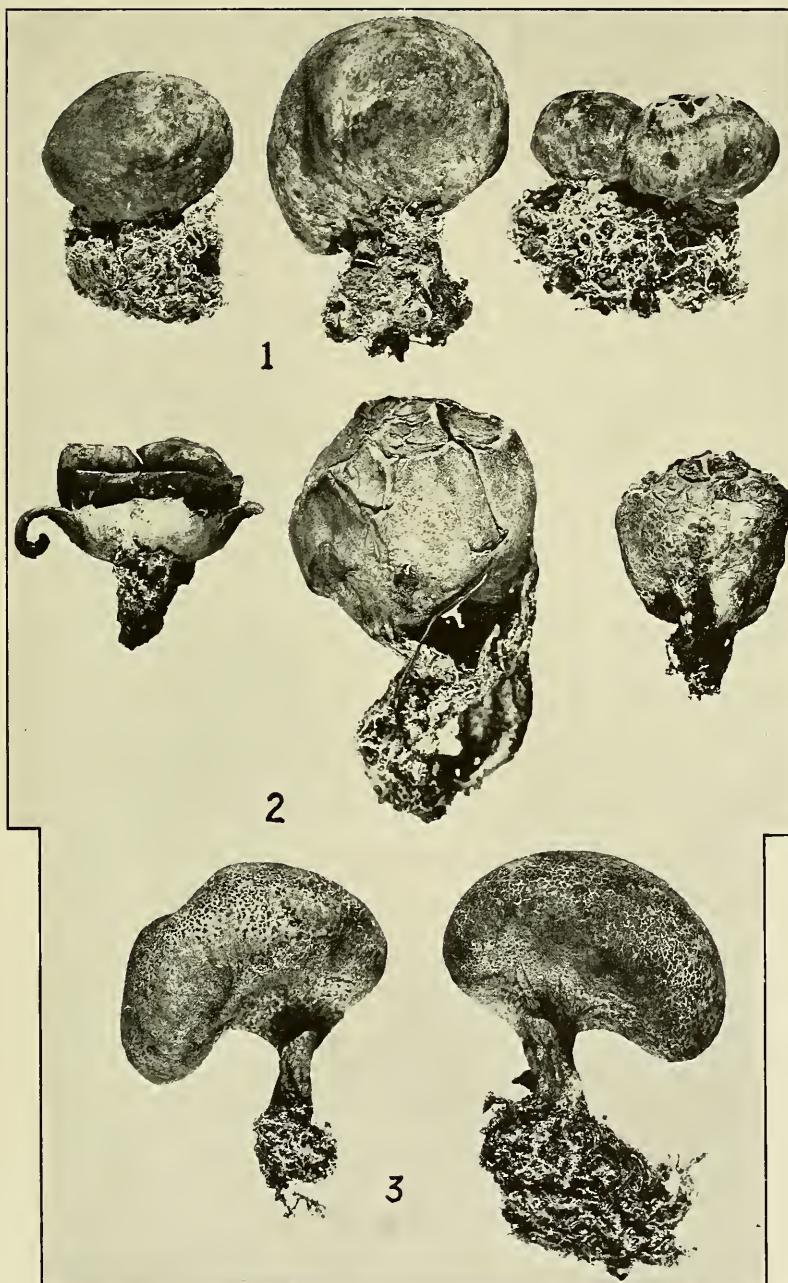
*j. S. vulgare* (Hornem.) Fr.—This has been recorded from most of the States by Cooke (1892, p. 240) and from New South Wales by Lloyd (*Letter 63, 1916, p. 3*). It is now known to consist of the two species *S. aurantium* and *S. cepa*, neither of which, as I have shown, has with certainty been collected in this biologic region.

#### Acknowledgements.

Once again I must express my indebtedness to Dr. J. B. Cleland for the loan of the large number of collections in his possession. I must also thank Mr. L. Rodway, Tasmania, Mr. C. C. Brittlebank, late of the Department of Agriculture, Victoria, and Mr. W. M. Carne, of the Department of Agriculture, Western Australia, for the loan or donations of specimens in their collections. Thanks are also due to Mr. H. Drake, of this Station, for the excellent photographs reproduced herein.

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*Scleroderma* spp.